In re the Application of: McCallister, Ronald D.	Date: 13 January 2009
Serial Number: 10/766,768	Group Art Unit: 2611
Filed: 27 January 2004	Examiner: BAYARD, Emmanuel
Title: *"Predistortion Circuit and Method for Compensating Linear Distortion in a Digital RF Communications Transmitter"*	Attorney Docket No: 2298-010

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Lowell W. Gresham
Signature

13 Jan. 2009
Date of Signature

Commissioner for Patents
P.O. Box 1450
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APPELLANT'S BRIEF

Dear Sir:

This Brief is filed pursuant to a Notice of Appeal mailed 27 October 2008.

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Real Party in Interest

The real party in interest of the present application, solely for purposes of identifying and avoiding potential conflicts of interest by board members due to working in matters in which the member has a financial interest, is Crestcom, Inc. Crestcom, Inc. is the assignee of record of the present application.

Related Appeals and Interferences

Appellant is aware of no related appeals, interference, and/or other proceedings relevant to this discussion.

Status of Claims

The Advisory Action dated 10 October 2008 to which this Appeal responds noted that claims 1-13, 15-37, 45-53, and 55-65 were pending. But this Appeal Brief is accompanied by an Amendment Under 37 CFR 41.33(b)(1) which cancels claims 30-37, 45-53, and 55-65. Accordingly, upon entry of the accompanying Amendment, claims 1-13 and 15-29 will be pending, claims 1-13 and 15-29 will stand rejected, and claims 1-13 and 15-29 will be on appeal.

Appendix A provides a clean copy of all claims on appeal.

Status of Amendments

One amendment has been filed subsequent to the rejections set forth in a Final Office Action, dated 29 July 2008. That one Amendment is a 37 CFR 41.33(b)(1) Amendment after Appeal. The 37 CFR 41.33(b)(1) Amendment after Appeal is being filed concurrently with this Appeal Brief to cancel claims 30-37, 45-53, and 55-65.

Summary of Claimed Subject Matter

This Summary of Claimed Subject Matter section references Figs. 1-3. Appendix C provides copies of Figs. 1-3 from the present application.

The claims on appeal include only one independent claim (i.e., claim 1). In the following discussion, the text of independent claim 1 is presented. Reference numbers in parentheses follow the name of items recited in the text. Bolded descriptions in brackets indicate the exemplary relevant Figures(s) and specification paragraph(s). It is to be understood that other portions of the specification and figures not cited herein may also provide examples of embodiments of elements of the claimed subject matter. It is also to be understood that the indicated examples are merely examples, and the scope of the claimed subject matter includes alternative embodiments and equivalents thereof. References herein to the specification and figures are thus intended to be exemplary and not limiting.

Independent Claim 1

Claim 1: A predistortion circuit (200) **{e.g., discussed in the specification in paragraphs [0060]-[0095] on pages 18-32 and illustrated in Figs. 1-3}** for compensating linear distortion **{e.g., discussed in the specification in paragraph [0020] on page 8}** introduced by analog-transmitter components (120) **{e.g., discussed in the specification in paragraphs [0055]-[0060] on pages 16-18 and illustrated in Fig. 1}** of a digital communications transmitter (100) **{e.g., discussed in the**

specification in paragraph [0047] on page 13 and illustrated in Fig. 1}, said predistortion circuit (200) comprising:

a source (202) **{e.g., discussed in the specification in paragraph [0062] on page 19 and illustrated in Fig. 2}** of a complex-forward-data stream (112) configured to digitally convey information within a bandwidth **{e.g., discussed in the specification in paragraphs [0062]-[0063] on pages 19-20 and illustrated in Figs. 1-2}**;

a digital equalizer section (234) **{e.g., discussed in the specification in paragraphs [0070]-[0075] on pages 22-25 and illustrated in Fig. 2}** coupled to said complex-forward-data-stream source (202) and configured to generate an equalized-complex-forward-data stream (118) **{e.g., discussed in the specification in paragraph [0075] on pages 24-25 and illustrated in Fig. 2}** and to pass said equalized-complex-forward-data stream (118) to said analog-transmitter components (120);

a feedback section (248) **{e.g., discussed in the specification in paragraph [0076] on page 25 and illustrated in Fig. 2}** comprising a complex-digital-subharmonic sampling downconverter (300) **{e.g., discussed in the specification in paragraphs [0087]-[0095] on pages 29-32 and illustrated in Figs. 2-3}** adapted to receive a feedback signal (117) **{e.g., discussed in the specification in paragraph [0076] on page 25 and illustrated in Figs. 1-2}** from said analog-transmitter components (120), and configured to provide a complex-return-data stream (254) at greater than or equal to said bandwidth **{e.g., discussed in the specification in paragraphs [0077], [0089], and [0094] on pages 26, 30, and 32 and illustrated in Figs. 2-3}**; and

a controller (286) **{e.g., discussed in the specification in paragraph [0086] on page 29 and illustrated in Fig. 2}** coupled

to said feedback section (248) and to said equalizer section (234) and configured so that said equalizer section (234) compensates for frequency dependent quadrature gain and phase imbalance **{e.g., discussed in the specification in paragraph [0073] on page 24}** introduced by said analog-transmitter components (120).

Grounds of Rejection to Be Reviewed on Appeal

Claims 1-2, 11-13, 15, 16, 18, 20, 22, 24, and 29 stand rejected under 35 U.S.C. 103(a) as being unpatentable over *Rahman et al.* (US Pub. No. 2003/0174783) in view of *Jeckeln et al.* (US Pub. No. 2002/0191710).

Dependent claims 3-10, 17, 19, 21, 23, and 25-28 stand rejected under 35 U.S.C. 103(a) as being unpatentable over *Rahman et al.* in view of *Jeckeln et al.* and in further view of *Sarca* (US Pub. No. 2005/0123066).

The following two grounds of rejection are presented for review:

1: Whether claims 1-2, 11-13, 15, 16, 18, 20, 22, 24, and 29 are unpatentable under 35 U.S.C. 103(a) over a combination of *Rahman et al.* in view of *Jeckeln et al.*.

2: Whether dependent claims 3-10, 17, 19, 21, 23, and 25-28 are unpatentable under 35 U.S.C. 103(a) over the combination of *Rahman et al.* in view of *Jeckeln et al.* and in further view of *Sarca*.

Arguments

Grounds of Rejection 1

Claims 1-2, 11-13, 15, 16, 18, 20, 22, 24, and 29

Independent Claim 1:

The final Office Action rejected independent claim 1 as being unpatentable under 35 U.S.C. 103(a) over a combination of *Rahman et al.* in view of *Jeckeln et al.*. A review of this rejection is respectfully requested.

In conjunction with appellant's claim 1, attention is respectfully directed to paragraph **[0011]** of appellant's Background section. This passage acknowledges that prior predistortion techniques had achieved some successes but that those successes were limited. And, the prior art predistortion techniques were inadequate in the face of more modern and strict regulatory requirements. In other words, the prior art predistortion techniques provide poor linear and/or nonlinear compensation. Appellant's invention as defined in claim 1 provides a solution to the poor performance of the prior art linear predistortion techniques.

Attention is respectfully directed to General Foods Corp. v. Studiengesellschaft Kohle mbH, 972 F.2d 1272, 23 USPQ 2d 1839, 1845 (Fed. Cir. 1992), which states the fundamental rule of claim construction that all limitations within a claim are material, as follows:

> What is claimed is what is *defined by the claim taken as a whole*, every limitation being material.

That is the fundamental rule of claim construction.

Appellant contends that the phrase "a complex-digital-subharmonic sampling downconverter" and the phrase "compensates for frequency dependent quadrature gain and phase imbalance" which are recited in claim 1 are material to a proper analysis of claim 1 and should not be ignored.

The Final Office Action alleged that *Rahman et al.* essentially taught all but one of the limitations recited in appellant's claim 1. The Advisory Action makes no further comment concerning the position stated in the Final Office Action.

The *Rahman et al.* reference discloses a transmit path correction system that corrects for the quadrature imbalance form of linear distortion in a transmit path of a transmitter. But quadrature imbalance is only one of many forms of linear distortion. *Rahman et al.* fails to address other forms of linear distortion, such as frequency response distortion, (e.g., "frequency dependent quadrature gain and phase imbalance") and *Rahman et al.* also fails to address nonlinear distortion.

The reviewer is respectfully directed to paragraph **[0020]** of appellant's specification for a summary of different types of linear distortion. Paragraphs **[0056]-[0059]** may also be reviewed for a compilation of different ways that specific analog transmitter components are responsible for different forms of linear distortion. Since the *Rahman et al.* reference fails to address forms of linear distortion beyond quadrature imbalance, *Rahman et al.* teaches only of a prior art linear predistortion technique that achieves poor performance.

Appellant's invention as recited in claim 1 is an improvement over the *Rahman et al.* teaching.

Frequency dependent quadrature gain and phase imbalance results from the use of filters whose transfer functions invariably apply different amounts of gain at one edge of the signal bandwidth than is applied at the other edge of the bandwidth. Such filters are typically included in upconversion chains after RF modulation, surrounding a power amplifier, and in other locations. The *Rahman et al.* reference fails to explicitly disclose such filters. Moreover, *Rahman et al.* fails to explicitly disclose any filter for removing a sideband resulting from the modulation of the *Rahman et al.* I/Q modulator 60, any filter included in an input matching network to a power amplifier, a power amplifier, or any filter included in an output matching network. But there would have been no point in explicitly disclosing such items because *Rahman et al.* is not concerned with "frequency dependent quadrature gain and phase imbalance" and such items are commonly used in the art.

Instead, *Rahman et al.* teaches of extracting a <u>baseband</u> feedback signal from the transmit path to use in correcting for quadrature imbalance. Thus, all filters that operate on an <u>RF</u> form of the communication signal and insert frequency dependent linear distortion exert no influence whatsoever over the *Rahman et al.* feedback signal. The frequency dependent quadrature gain and phase imbalance introduced by such components cannot be removed by the *Rahman et al.* system because the *Rahman et al.* feedback signal is extracted upstream of such RF components. In other words, the *Rahman et al.* feedback signal conveys no information about the distorting influence of RF filters that

introduce frequency dependent quadrature gain and phase imbalance. Without any information about the distorting influence of RF filters, the *Rahman et al.* system is powerless to correct for such forms of linear distortion.

Accordingly, *Rahman et al.* fails to teach of any mechanism or need to compensate for frequency dependent quadrature gain and phase imbalance. As a consequence, the *Rahman et al.* system does a poor job of compensating for linear distortion. But, compensating for all forms of linear distortion is not the problem to which the *Rahman et al.* system is directed. Rather, *Rahman et al.* is directed only to the problem of quadrature imbalance correction.

The failure to teach of a way to compensate for frequency dependent quadrature gain and phase imbalance or a need for such compensation is only one of the features recited in appellant's claim 1 that is not taught by *Rahman et al.*. The *Rahman et al.* reference also fails to teach or suggest of a "digital-subharmonic-sampling downconverter" to process its feedback signal. The Final Office Action acknowledges that *Rahman et al.* fails to teach or suggest of a "digital-subharmonic-sampling downconverter."

The Final Office Action alleges that *Jeckeln et al.* teaches of a complex digital sampling down converter functionally equivalent to the claimed digital-subharmonic-sampling downconverter. This is a misrepresentation of that which *Jeckeln et al.* fully and fairly teaches to those skilled in the art. As stated in <u>Ingersoll-Rand Co. v. Brunner & Lay, Inc.</u> 1177 USPQ 112, 116 (5^{th} Cir 1973):

> Moreover, it is not realistic to pick and choose from any one reference only so much of it as will support a given position, to the exclusion of other parts necessary to the full appreciation of what such reference fairly suggests to one of ordinary skill in the art (emphasis supplied).

Jeckeln et al. teaches of a predistortion device that uses a digital receiver. The *Jeckeln et al.* predistortion device is addressed to the problem of linearizing a power amplifier (PA) 34. In other words, *Jeckeln et al.* teaches a technique for applying nonlinear predistortion in an RF IQ modulator 46 so that the output from PA 34 appears more linear. *Jeckeln et al.* teaches a technique for ameliorating nonlinear distortion at the output of PA 34, but no technique or need for compensating for linear distortion in general, and certainly no technique or need for compensating the frequency dependent quadrature gain and phase imbalance type of linear distortion that is recited in appellant's claim 1.

Accordingly, neither *Rahman et al.* nor *Jeckeln et al.* teach or suggest of any problem related to the frequency dependent quadrature gain and phase imbalance type of linear distortion. Rather that teaching comes only from appellant's specification.

Long settled patent law, as stated in In re Shaffer, 108 USPQ 326 at 309 (C.C.P.A. 1956), for example, is precisely on point here:

> In fact, a person having the references before him who was not cognizant of appellant's disclosure would not be informed that the problem solved by appellant ever existed. Therefore, can it be said that these references which never recognized appellant's problem would have suggested its solution? We think not, and

> therefore feel that the references were improperly combined since there is no suggestion in either of the references that they can be combined to produce appellant's result.

Since neither reference even recognizes the problem to which appellant's claim 1 is directed, their combination cannot be used to suggest appellant's solution, as set forth in claim 1. A reversal of the rejection of claim 1 for being an improper combination of references is respectfully requested.

Moreover, as stated in In re Fritch, 23 USPQ 2d 1780, 1784 (Fed. Cir. 1992):

> It is impermissible to use the claimed invention as an instruction manual or "template" to piece together the teachings of the prior art so that the claimed invention is rendered obvious. This court has previously stated that "[o]ne cannot used hindsight reconstruction to pick and choose among isolated disclosures in the prior art to deprecate the claimed invention".

Evidence indicating that hindsight has been used in making an obviousness rejection is well-established grounds for reversing obviousness rejections. As stated in W.L. Gore & Associates, Inc. v. Garlock, Inc., 220 USPQ 303, 312-13 (Fed. Cir. 1983), cert denied, 469 U.S. 851 (1984):

> To imbue one of ordinary skill in the art with knowledge of the invention in suit, when no prior art reference or references of record convey or suggest that knowledge, is to fall victim to the insidious effect of a hindsight syndrome wherein that which only the inventor taught is used against its teacher.

Since the problems associated with frequency dependent quadrature gain and phase imbalance are taught only in appellant's specification and not taught or suggested by the

prior art, and since the solution for compensating for frequency dependent quadrature gain and phase imbalance are recited in claim 1 and neither taught nor suggested by the prior art, it is error to rely upon hindsight obtained from appellant's specification to pick and choose hindsight-selected features from the hindsight-selected combination of references used in the Final Office Action to reject appellant's claim 1. A reversal of the rejection of claim 1 for using hindsight obtained from appellant's specification and found nowhere else in the prior art as the understanding about what the prior art fully and fairly teaches when considered alone and particularly when considered in conjunction with the above-mentioned reason is respectfully requested.

The *Jeckeln et al.* reference discloses that a feedback signal used in generating nonlinear predistortion is not phase-coherent with the forward RF signal processed through IQ modulator 46 and power amplifier (PA) 34. And, *Jeckeln et al.* uses out-of-band energy in a feedback loop that applies nonlinear predistortion at IQ modulator 46 in a way intended to attenuate the out-of-band energy.

While claim 1 is directed to "a predistortion circuit for compensating <u>linear</u> distortion," appellant's specification describes a system that compensates for both linear and nonlinear distortion. Appellant's system uses different blocks to accomplish the different tasks (e.g, see blocks 224 and 244 in appellant's Fig. 2). Appellant believes that the nonlinear compensation technique taught by *Jeckeln et al.* is not particularly relevant to the discussion of linear distortion compensation which is the subject of claim 1, but the Final

Office Action has made this an issue by relying on *Jeckeln et al*. Thus, it is instructive to note that the form of nonlinear compensation taught by *Jeckeln et al*. has been recognized as achieving poor nonlinear predistortion performance. Attention is respectfully directed to paragraph **[0016]** in appellant's Background section which discusses the problems encountered with the type of predistorter that includes an inversion operation, such as taught in the distorting generator 42 depicted in Fig. 3 of *Jeckeln et al*. And, attention is respectfully directed to paragraph **[0018]** in appellant's Background section which discusses problems encountered in using high resolution A/D's and in processing the out-of-band portion of the feedback signal, as taught in *Jeckeln et al*.

As stated in In re Gordon et al., 221 USPQ 1125 at 1127 (Fed. Cir. 1984) and repeated in In re Laskowski, 10 USPQ 1397 at 1398 (Fed. Cir. 1989):

> The mere fact that the prior art could be so modified would not have made the modification obvious unless the prior art suggested the desirability of the modification.

Those skilled in the art would find no suggestion for the desirability of modifying the *Rahman et al*. teaching which the Final Office Action seems to have found in the *Rahman et al*. and *Jeckeln et al*. references after receiving the benefit of hindsight obtained from appellant's application. Those skilled in the art would not be motivated to combine a linear predistortion technique (e.g., *Rahman et al*.) which achieves performance so poor that it is inadequate for use in meeting more modern regulatory requirements with a nonlinear predistortion technique (e.g., *Jeckeln et al*.) which accomplishes nothing toward compensating for linear distortion

and which achieves performance so poor in compensating for nonlinear distortion that is also inadequate for meeting more modern regulatory requirements. A reversal of the rejection of claim 1 for lacking a suggestion to support the proffered combination of references when considered alone and particularly when considered in conjunction with the above-mentioned reasons is respectfully requested.

In addressing its nonlinear predistortion problem, *Jeckeln et al.* teaches of extracting RF signals at the input and output of PA 34, and then performing RF translation "down to within an alias-free sampling range from DC up to 35 MHz" (*Jeckeln et al.*, paragraph **[0066]**). RF translators which translate from RF to IF are well known in the art. They perform a downconversion. They also introduce frequency-dependent linear distortion.

If *Jeckeln et al.* were concerned with compensating for frequency dependent quadrature gain and phase imbalance, which they are not, this RF translator would cause the *Jeckeln et al.* system to fail. Failure would result because distortion introduced in the generation of the feedback signal would not be distinguished by the blocks that process the feedback signal (e.g., module 62 and generator 42 of *Jeckeln et al.*) from distortion introduced by components that generate the forward-propagating communication signal. If such blocks were configured to compensate for frequency-dependent linear distortion, which they are not in *Jeckeln et al.*, they would then overcompensate by predistorting the forward-propagating communication signal to account for distortion introduced only in the feedback signal and not appearing in the forward-propagating communication signal at all.

The *Jeckeln et al.* RF translators 50 and 56 presumably include an IF filter at the output of the RF translators, between the downconversion operation and the A/D operation. RF translators 50 and 56 would include such an IF filter in order to eliminate an unwanted sideband and noise so that the downconverted signal would achieve the "alias-free sampling range from DC up to 35 MHz" that *Jeckeln et al.* calls for. *Jeckeln et al.* also presumably includes an RF filter prior to the downconversion operation to reduce intermodulation products in the band of interest because such RF filters are conventionally needed before downconversion operations and nothing in *Jeckeln et al.* indicates otherwise. These filters introduce frequency-dependent linear distortion. Those skilled in the art would clearly understand that *Jeckeln et al.* includes such filters because *Jeckeln et al.* expressly states that it achieves an alias-free sampling range of from DC up to 35MHz. Without such filters, *Jeckeln et al.* would not achieve its alias-free sampling range of from DC up to 35 MHz.

Following the analog downconversion in RF translators 50 and 56, *Jeckeln et al.* performs a conventional Nyquist-rate sampling operation in digital receivers 54 and 60 in converting the frequency-translated signals from RF translators 50 and 56 into digital streams. An analog-to-digital conversion operation is performed in digital receivers 54 and 60, and a conversion from a combined signal into two reduced-rate complex signal streams is performed in digital receivers 54 and 60. *Jeckeln et al.* indicates that "a sampling rate of 70 MHz is adequate" (*Jeckeln et al.*, paragraph [0066]), which meets the requirements of the Nyquist sampling rate for the DC to 35MHz band of

interest.

The Nyquist sampling rate (i.e., double the highest frequency in the band of interest) does not accomplish the equivalent of subharmonic sampling. Appendix B of this Appeal Brief includes a definition of "subharmonic", along with the title page and copyright pages of the dictionary from which the definition was obtained. As that definition confirms, those skilled in the art will understand that subharmonic sampling occurs at a rate which is a submultiple of the frequency to which it is referenced. In order for *Jeckeln et al.* to be engaged in subharmonic sampling, *Jeckeln et al.* would need to sample at a rate less than 35 MHz rather that the Nyquist rate of 70MHz that *Jeckeln et al.* explicitly teaches.

Accordingly, the expressly stated goal of *Jeckeln et al.* is to perform alias-free Nyquist sampling, which requires the use of filters in RF translators 50 and 56. *Jeckeln et al.* performs no subharmonic sampling but teaches the precise opposite, and the Final Office Action characterization of the *Jeckeln et al.* teaching as being equivalent to subharmonic sampling is a mischaracterization of that which is fully and fairly understood by those of skill in the art.

Claim 1 recites the limitation of "a complex-digital-subharmonic sampling downconverter". The Final Office Action acknowledges that the primary reference, *Rahman et al.*, fails to teach of this limitation. As discussed above, the secondary reference, *Jeckeln et al.*, likewise fails to teach this limitation. *Jeckeln et al.* fails to teach this limitation because *Jeckeln et al.* fails to teach of any subharmonic

sampling whatsoever. Rather than teach subharmonic sampling, *Jeckeln et al.* teaches of an RF translator that introduces a frequency-dependent distortion that is not introduced by using the "complex-digital-subharmonic sampling downconverter" recited in claim 1.

As stated in In re GPAC Inc., 57 F.3d 1573, 35 U.S.P.Q.2d 1116, 1123 (Fed. Cir. 1995):

> "[The Board] may not...resort to speculation, unfounded assumptions or hindsight reconstruction to supply deficiencies in its factual basis."

As further stated in Ex parte Wolters and Kuypers, U.S.P.Q. 735, 737 (PTO Bd. App. 1979):

> An Examiner's burden of supporting his holding of unpatentability is not met by "assuming" the presence of a component that is missing from applied art.

It was improper for the Final Office Action to speculate and assume that the downconversion followed by Nyquist sampling taught by *Jeckeln et al.* is "functionally equivalent" to the "complex-digital-subharmonic sampling downconverter" recited in appellant's claim 1. Rather, *Jeckeln et al.* teaches away from the use of a complex-digital-subharmonic sampling downconverter by teaching the precise opposite and by teaching an approach that introduces frequency-dependent linear distortion, the removal of which is the problem that the present invention as recited in claim 1 addresses.

No combination of *Rahman et al.* and *Jeckeln et al.* can result in a system that incorporates appellant's recited digital-subharmonic-sampling downconverter limitation because neither *Rahman et al.* nor *Jeckeln et al.* teach of such a thing.

Accordingly, the combination of *Rahman et al.* and *Jeckeln et al.* fails to render appellant's claim 1 obvious. A reversal of the rejection of claim 1 for this reason when considered alone and particularly when considered in conjunction with the above-mentioned reasons is respectfully requested.

Dependent Claims 2, 11-13, 15-16, 18, 20, 22, 24, and 29:

Dependent claims 2, 11-13, 15-16, 18, 20, 22, 24, and 29 were rejected as being obvious over the combination of *Rahman et al.* and *Jeckeln et al.*

Claims 2, 11-13, 15-16, 18, 20, 22, 24, and 29 depend, directly or indirectly, from independent claim 1. Claims 2, 11-13, 15-16, 18, 20, 22, 24, and 29 are allowable at least due to their dependency on claim 1. A reversal of the rejection of claims 2, 11-13, 15-16, 18, 20, 22, 24, and 29 is respectfully requested.

Grounds of Rejection 2
Dependent Claims 3-10, 17, 19, 21, 23, and 25-28

Dependent claims 3-10, 17, 19, 21, 23, and 25-28 were rejected as being obvious over the combination of *Rahman et al.*, *Jeckeln et al.* and *Sarca*. *Rahman et al.* and *Jeckeln et al.* were discussed above.

Sarca teaches nothing to further the teaching of *Rahman et al.* and *Jeckeln et al.* with respect to the "digital-subharmonic sampling downconverter" limitation of appellant's independent claim 1 or of appellant's recited "compensates for frequency

dependent quadrature gain and phase imbalance" limitation of claim 1. In fact, *Sarca* suggests the use of a similar feedback signal downconversion scheme as is taught by *Jeckeln et al.* Referring to Figs. 4 or 5 of *Sarca*, the feedback signal is downconverted at mixer 62, and then filtered at LPF 64 prior to digital conversion in ADC 66. The use of mixer 62 and LPF 62 suggests conventional Nyquist sampling at ADC 66 rather than the use of subharmonic sampling. The use of LPF 64 introduces frequency-dependent distortion, and no structure, explicit teaching, or suggestion provides any basis for removing the frequency-dependent distortion introduced by LPF 64. As a result, *Sarca* cannot adequately compensate for frequency dependent quadrature gain and phase imbalance.

Accordingly, independent claim 1 is allowable over the *Sarca* reference, alone or in combination with *Rahman et al.* and *Jeckeln et al.*

Claims 3-10, 17, 19, 21, 23, and 25-28 depend, directly or indirectly, from independent claim 1. Claims 3-10, 17, 19, 21, 23, and 25-28 are allowable at least due to their dependency on claim 1. A reversal of the rejection of claims 3-10, 17, 19, 21, 23, and 25-28 is respectfully requested.

Conclusion

Claims 1-13 and 15-29 are included in this Appeal.

The rejection of the sole independent claim (i.e., claim 1) and all other claims on appeal here as being unpatentable under 35 U.S.C. 103(a) over *Rahman et al.* in view of *Jeckeln et al.* is

believed to be improper. The examiner has failed to meet the burden of showing that any prior art of record teaches or suggests of "a complex-digital-subharmonic sampling downconverter." To the contrary, the *Jeckeln et al.* reference, which was alleged by the Final Office Action to teach something functionally equivalent, teaches the precise opposite: Nyquist sampling. The use of Nyquist sampling as taught by *Jeckeln et al.* necessitates the inclusion of an RF translator that introduces the very frequency-dependent linear distortion that is avoided by the use of appellant's recited complex-digital-subharmonic sampling downconverter and that allows appellant's predistortion circuit to improve compensation for "frequency dependent quadrature gain and phase imbalance".

Appellant believes that the arguments above fully respond to every outstanding ground of rejection and that the contested claims should be found allowable.

Respectfully submitted,

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Appendix A -- Claims on Appeal

This Appendix is 12 pages, including this cover page, and contains a clean double-spaced copy of the claims on appeal.

Claim 1: A predistortion circuit for compensating linear distortion introduced by analog-transmitter components of a digital communications transmitter, said predistortion circuit comprising:

a source of a complex-forward-data stream configured to digitally convey information within a bandwidth;

a digital equalizer section coupled to said complex-forward-data-stream source and configured to generate an equalized-complex-forward-data stream and to pass said equalized-complex-forward-data stream to said analog-transmitter components;

a feedback section comprising a complex-digital-subharmonic sampling downconverter adapted to receive a feedback signal from said analog-transmitter components, and configured to provide a complex-return-data stream at greater than or equal to said bandwidth; and

a controller coupled to said feedback section and to said equalizer section and configured so that said equalizer section compensates for frequency dependent quadrature gain and phase imbalance introduced by said analog-transmitter components.

Claim 2: A predistortion circuit as claimed in claim 1 wherein said analog-transmitter components include a power amplifier having an input and an output, and said feedback

section comprises:

a first analog input adapted to receive a first RF-analog signal from said power amplifier input; and

a second analog input adapted to receive a second RF-analog signal from said power amplifier output.

Claim 3: A predistortion circuit as claimed in claim 2 wherein said controller is configured to compensate for linear distortion in an RF-analog signal present at said input of said power amplifier, then compensate for linear distortion in an amplified RF signal present at said output of said power amplifier.

Claim 4: A predistortion circuit as claimed in claim 1 wherein said equalizer section comprises:

a non-adaptive equalizer configured to be programmed with filter coefficients; and

an adaptation engine coupled to said non-adaptive equalizer and configured to implement an estimation-and-convergence algorithm which determines said filter coefficients.

Claim 5: A predistortion circuit as claimed in claim 4 wherein said non-adaptive equalizer processes said complex-forward-data stream, and said adaptation engine is responsive to

said complex-forward-data stream and said complex-return-data stream.

Claim 6: A predistortion circuit as claimed in claim 4 wherein:

said non-adaptive equalizer is a complex equalizer having an in-phase path, a quadrature path, an in-phase-to-quadrature path, and a quadrature-to-in-phase path;

a first set of said filter coefficients is programmed in said in-phase and quadrature paths, and a second set of said filter coefficients is programmed in said in-phase-to-quadrature and quadrature-to-in-phase paths; and

said adaptation engine accommodates a partial complex equalizer and has first and second paths, said first and second paths being configured in one mode to determine said filter coefficients for said in-phase and quadrature paths, and being configured in another mode to determine said filter coefficients for said in-phase-to-quadrature and quadrature-to-in-phase paths.

Claim 7: A predistortion circuit as claimed in claim 1 wherein said equalizer section implements an estimation-and-convergence algorithm to determine filter coefficients that compensate for said frequency dependent quadrature gain and

phase imbalance.

Claim 8: A predistortion circuit as claimed in claim 7 wherein:

said estimation-and-convergence algorithm is responsive to said complex-forward-data stream and to said complex-return-data stream;

said complex-forward-data stream and said complex-return-data stream exhibit forward-error and return-error levels, respectively, with said return-error level being greater than said forward-error level; and

said estimation-and-convergence algorithm is configured to transform increased algorithmic processing time into reduced effective-error level for said complex-return-data stream.

Claim 9: A predistortion circuit as claimed in claim 7 wherein said estimation-and-convergence algorithm causes said equalizer section to converge at said filter coefficients after processing a multiplicity of samples from said complex-return-data stream.

Claim 10: A predistortion circuit as claimed in claim 7 wherein said

said estimation-and-convergence algorithm is responsive to

said complex-forward-data stream and to said complex-return-data stream;

said complex-forward-data stream and said complex-return-data stream exhibit a forward-error level and a return-error level, respectively, with said return-error level being greater than said forward-error level; and

said estimation-and-convergence algorithm controls a rate of convergence upon said filter coefficients to achieve a predetermined effective return-error level that is less than said return-error level.

Claim 11: A predistortion circuit as claimed in claim 1 wherein said equalizer section implements a complex equalizer.

Claim 12: A predistortion circuit as claimed in claim 1 wherein:

said complex-forward-data stream exhibits a forward resolution; and

said complex-return-data stream exhibits a return resolution less than said forward resolution.

Claim 13: A predistortion circuit as claimed in claim 12 wherein said feedback section generates said complex-return-data stream so that said return resolution is at most four bits less

than said forward resolution.

Claim 15: A predistortion circuit as claimed in claim 1 additionally comprising a programmable delay element coupled between said complex-forward-data-stream source and said feedback section, said programmable delay element being configured to produce a delayed-complex-forward-data stream temporally aligned with said complex-return-data stream.

Claim 16: A predistortion circuit as claimed in claim 15 wherein:

said complex-forward-data stream propagates through said predistortion circuit in response to a clock signal; and

said programmable delay element includes an integral section that delays at least a portion of said complex-forward-data stream by an integral number of cycles of said clock signal and includes a fractional section that delays said portion of said complex-forward-data stream by a fraction of a cycle of said clock signal.

Claim 17: A predistortion circuit as claimed in claim 15 wherein:

said predistortion circuit additionally comprises a correlator having inputs coupled to said programmable delay

element and to said feedback section and having an output coupled to said controller; and

said controller and said correlator are configured to implement an estimation-and-convergence algorithm to bring said delayed-complex-forward-data stream into temporal alignment with said complex-return-data stream.

Claim 18: A predistortion circuit as claimed in claim 15 wherein said controller is configured to cause said programmable delay element to temporally align said delayed-complex-forward-data stream with said complex-return-data stream prior to causing said equalizer section to compensate for said frequency dependent quadrature gain and phase imbalance introduced by said analog-transmitter components.

Claim 19: A predistortion circuit as claimed in claim 15 wherein:

said equalizer section comprises an adaptive equalizer configured to determine filter coefficients that compensate for said frequency dependent quadrature gain and phase imbalance; and

said adaptive equalizer increases correlation between said delayed-complex-forward-data stream and said complex-return-data stream in determining said filter coefficients.

Claim 20: A predistortion circuit as claimed in claim 1 wherein:

said analog-transmitter components include a band-pass filter which inserts a band-pass-filter delay; and

said predistortion circuit additionally comprises a phase rotator configured to rotate one of said complex-forward-data and complex-return-data streams relative to the other to compensate for said band-pass-filter delay.

Claim 21: A predistortion circuit as claimed in claim 20 wherein said phase rotator is configured to implement an estimation-and-convergence algorithm to determine an amount of phase rotation that compensates for said band-pass-filter delay.

Claim 22: A predistortion circuit as claimed in claim 20 wherein said controller is configured to cause said phase rotator to compensate for said band-pass-filter delay prior to causing said equalizer section to compensate for said frequency dependent quadrature gain and phase imbalance introduced by said analog-transmitter components.

Claim 23: A predistortion circuit as claimed in claim 20 wherein:

said equalizer section comprises an adaptive equalizer configured to determine filter coefficients that compensate for said frequency dependent quadrature gain and phase imbalance; and

said adaptive equalizer increases correlation between said complex-forward-data and complex-return-data streams after rotation of one of said complex-forward-data and complex-return-data streams relative to the other in determining said filter coefficients.

Claim 24: A predistortion circuit as claimed in claim 1 wherein said equalizer section includes a first equalizer configured to filter said complex-forward-data stream and a second equalizer configured to filter said complex-return-data stream.

Claim 25: A predistortion circuit as claimed in claim 24 wherein:

said first equalizer is a non-adaptive equalizer programmed with forward-filter coefficients;

said second equalizer is a non-adaptive equalizer programmed with return-filter coefficients; and

said equalizer section additionally includes an adaptation engine selectively coupled to said first and second equalizers

and configured to implement an estimation-and-convergence algorithm which determines said forward-filter and return-filter coefficients.

Claim 26: A predistortion circuit as claimed in claim 24 wherein:

said analog-transmitter components include a power amplifier having an input and an output;

said feedback section has a first analog input adapted to receive a first RF-analog signal from said power amplifier input and a second analog input adapted to receive a second RF-analog signal from said power amplifier output;

said controller is configured to cause said feedback section to monitor said first RF-analog signal while adjusting said first equalizer to compensate for linear distortion at said input of said power amplifier, then cause said feedback section to monitor said second RF-analog signal while further adjusting said first equalizer to compensate for linear distortion at said output of said power amplifier.

Claim 27: A predistortion circuit as claimed in claim 26 wherein said controller is configured to, after adjusting said first equalizer to compensate for linear distortion at said output of said power amplifier, monitor said second RF-analog

signal while adjusting said second equalizer to further compensate for linear distortion at said output of said power amplifier.

Claim 28: A predistortion circuit as claimed in claim 27 wherein:

said first equalizer is adjusted to increase correlation between said second RF-analog signal and a first signal responsive to said complex-forward-data stream and having a first bandwidth; and

said second equalizer is adjusted to increase correlation between said second RF-analog signal and a second signal responsive to said complex-forward-data stream and having a second bandwidth wider than said first bandwidth.

Claim 29: A predistortion circuit as claimed in claim 24 wherein:

said analog section includes a power amplifier which exhibits a gain; and

said predistortion circuit additionally comprises an adjustable attenuation circuit configured to compensate for said gain of said power amplifier and positioned to process said complex-return-data stream before filtering in said second equalizer.

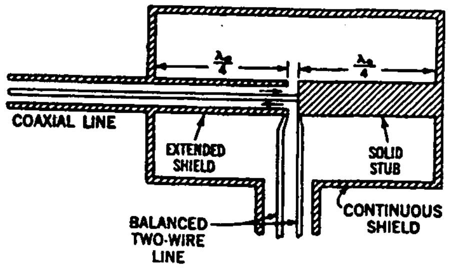
Appendix B -- Evidence

This Appendix is 4 pages long, including this cover page, and contains page number 448, the title page, and the copyright notice page of: "McGraw-Hill Electronics Dictionary, sixth edition" by Neil Sclater and John Markus, McGraw-Hill, 1997. A definition for the word "subharmonic" is included toward the bottom of the second column on page 448.

strontium [Sr] A metallic element that is used in cathodes of phototubes to obtain maximum response to ultraviolet radiation. It has an atomic number of 38.

strontium 90 A radioisotope that has a half-life of about 25 years. It is also called radio strontium.

stub 1. A short section of transmission line, open or shorted at the far end, connected in parallel with a transmission line to match the impedance of the line to that of an antenna or transmitter. 2. A solid projection one quarter-wavelength long that forms an insulating support in a waveguide or cavity.

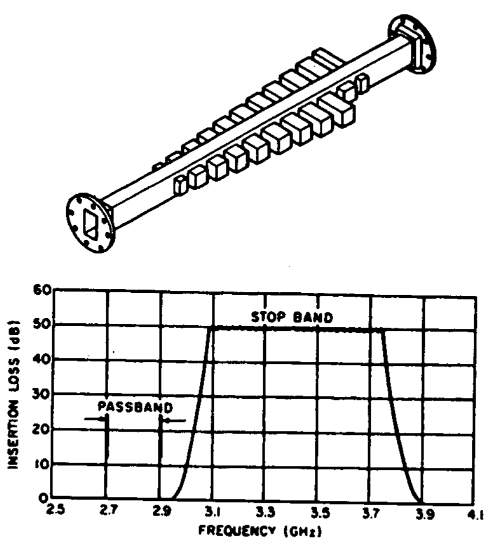


Stub in a cavity to support a conductor during conversion from coaxial line to balanced two-wire line.

stub-matching The use of a stub to match a transmission line to an antenna or load. Matching depends on the spacing between the two wires of the stub, the position of the shorting bar, and the point at which the transmission line is connected to the stub.

stub-supported line A transmission line that is supported by short-circuited quarter-wave sections of coaxial line. A stub exactly a quarter-wavelength long acts as an insulator because it has infinite reactance.

stub-tuned filter A microwave stopband filter that consists of a number of T junctions of different sizes, inserted in a waveguide to produce high attenuation over a band of frequencies. It can suppress undesired frequencies that can be up to the fourth harmonic.



Stub-tuned filter for 2.7–2.9 GHz waveguide, providing 50-dB attenuation between 3.1 and 3.7 GHz.

stub tuner An adjustable shorted stub for adjusting a transmission line for maximum power transfer.

studio A room in which television or radio programs are produced.

stylus [plural **styli**] The part of a phonograph pickup that follows the modulations of a record groove and transmits the resulting mechanical motions to the transducer element of the pickup for conversion to corresponding AF signals. It is also called a *needle* and a reproducing stylus.

s-type negative resistance A voltage-stable negative resistance in which a given current in the operating range can have three different possible values of terminal voltage. Examples include tunnel diodes and the common-emitter input of a point-contact transistor.

styrofoam A foamed plastic that exhibits low water absorption, is light in weight, and can float. It is also a thermal insulator and can be molded to specific shapes to conform to and support electronic equipment during shipment. It is also available in pellet form for use as a shock-absorbing package fill. However, only conductive styrofoam should be in contact with ESD-sensitive components and circuits.

subassembly Two or more parts joined together to form a functional entity but which have replaceable components and are subordinate to a higher-level assembly, product, or system. Examples include completed circuit boards, printer heads, speaker cabinets, and tape decks.

subatomic A reference to particles smaller than atoms, such as electrons, protons, and neutrons.

subaudio *Infrasonic.*

subcarrier 1. A carrier that is applied as a modulating wave to modulate another carrier. 2. *Chrominance subcarrier.*

subcarrier band A band associated with a given subcarrier and specified in terms of maximum subcarrier deviation.

subcarrier discriminator A discriminator that demodulates a telemetering subcarrier frequency.

subcarrier frequencies *Channels* assigned for specific applications, such as telemetry. There are standardized subcarrier channels for FM/FM telemetry systems. There are 18 IRIG standardized subcarrier bands for telemetry.

subcarrier oscillator 1. The crystal oscillator that operates at the chrominance subcarrier or burst frequency of 3.579545 MHz in a color television receiver. This oscillator, synchronized in frequency and phase with the transmitter master oscillator, furnishes the continuous subcarrier frequency required for demodulators in the receiver. 2. An oscillator for a telemetering system that translates variations in an electrical quantity into variations of a frequency-modulated signal at a subcarrier frequency.

subharmonic A sinusoidal quantity that has a frequency which is an integral submultiple of the frequency of some other sinusoidal quantity to which it is referred. A third subharmonic would be one-third the fundamental or reference frequency.

subject copy The text document or graphic that is to be transmitted over the public telephone lines by a *facsimile machine.* See also *facsimile copy.*

subliminal Below the threshold of conscious responsiveness to a stimulus. Applications include behavior modification that involves audio or video motivational stimuli.

McGRAW-HILL ELECTRONICS DICTIONARY

SIXTH EDITION

NEIL SCLATER

JOHN MARKUS

McGraw-Hill

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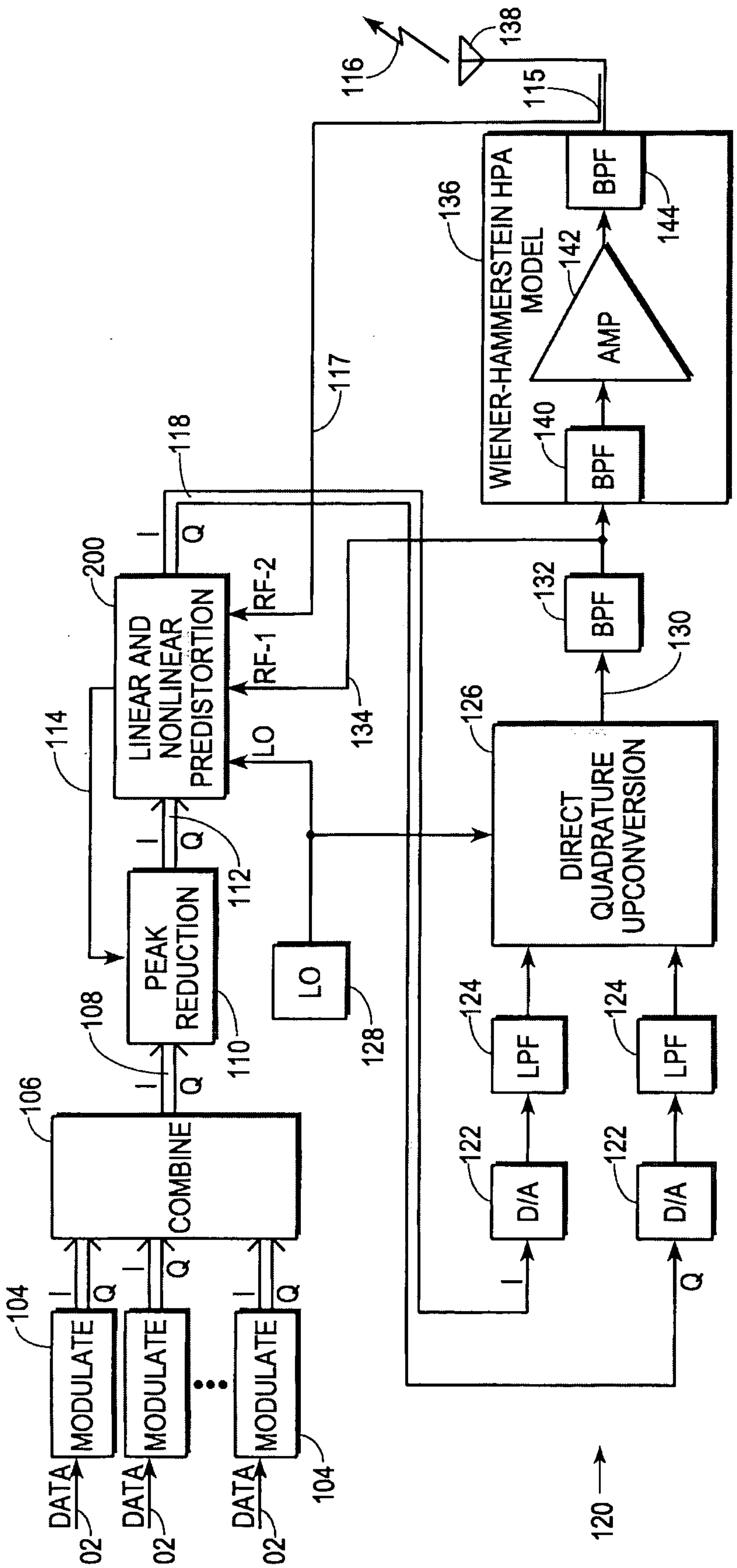
Appendix C -- Figures

This Appendix is 4 pages long, including this cover page, and contains drawing sheets 1-3 from the 12 drawing sheets included in this application. These drawing sheets 1-3 include a clean copy of Figs. 1-3.



DATA
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MODULATE
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COMBINE
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PEAK REDUCTION
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112
114
LINEAR AND NONLINEAR PREDISTORTION
200
LO
RF-1
RF-2
118
117
116
115
138
LO
128
134
D/A
122
LPF
124
DIRECT QUADRATURE UPCONVERSION
126
130
BPF
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WIENER-HAMMERSTEIN HPA MODEL
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BPF
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AMP
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BPF
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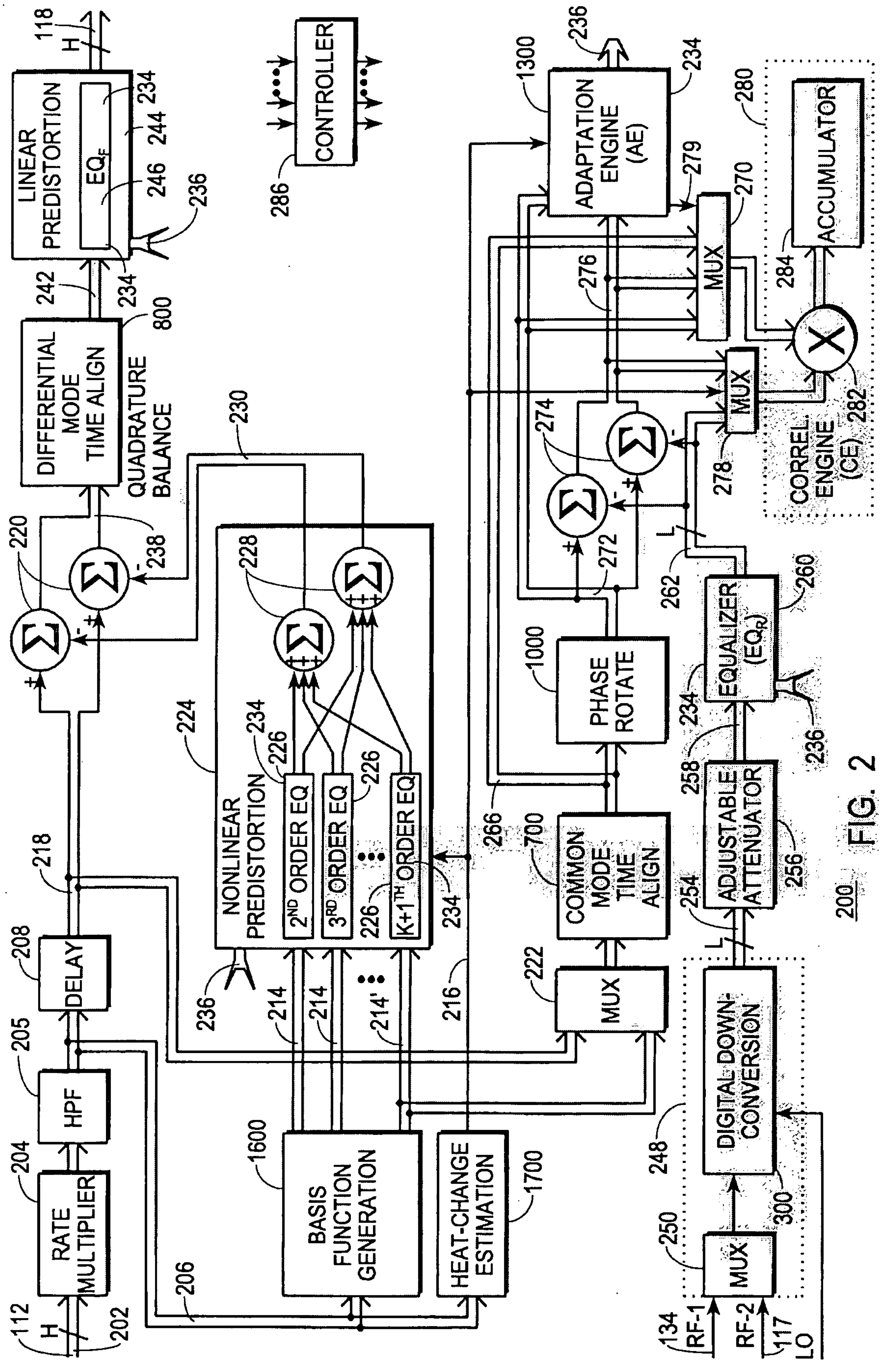
FIG. 1


RATE MULTIPLIER
HPF
DELAY
DIFFERENTIAL MODE TIME ALIGN
QUADRATURE BALANCE
LINEAR PREDISTORTION
EQ
CONTROLLER
NONLINEAR PREDISTORTION
2ND ORDER EQ
3RD ORDER EQ
K+1TH ORDER EQ
BASIS FUNCTION GENERATION
HEAT-CHANGE ESTIMATION
MUX
COMMON MODE TIME ALIGN
PHASE ROTATE
ADAPTATION ENGINE (AE)
ACCUMULATOR
CORREL. ENGINE (CE)
DIGITAL DOWN-CONVERSION
ADJUSTABLE ATTENUATOR
EQUALIZER (EQR)
RF-1
RF-2
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117

FIG. 2

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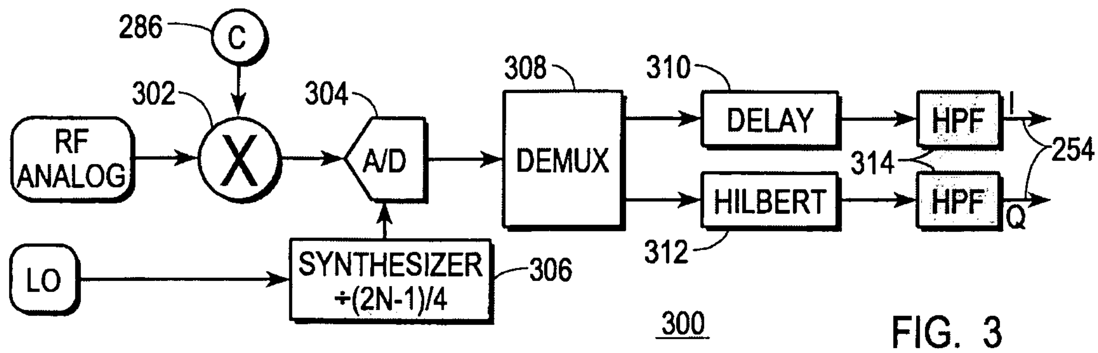

FIG. 3

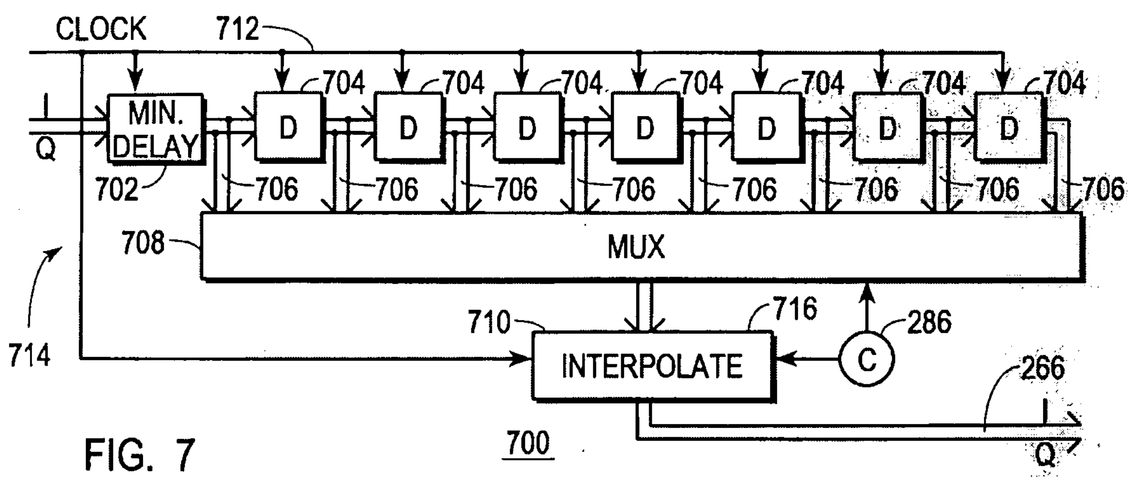

FIG. 7

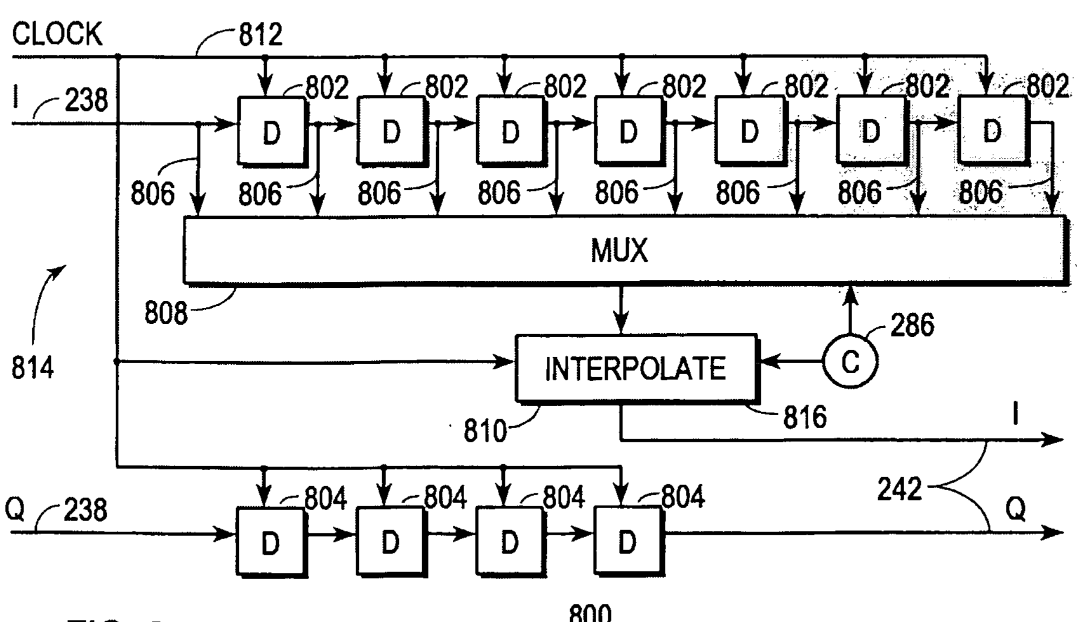

FIG. 8

Appendix D - Related Proceedings Appendix

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